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# **Maximize Tensile Strength in Aluminium Alloy Joints Using Parametric Optimisation of Linear Friction Welding**

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**ABSTRACT:** In this examination, the FSW joints of 6061-T6 aluminum composite and ultra-low carbon steel, in which the mixing pin was dove into steel (0.2mm) metal and remove the steel surface layer. The as-welded joint microstructures and properties were explore. The lap joint between A6061-T6 aluminum combination and ultra-low carbon steel was effectively delivered by FSW. Increasing the propelling pace of an instrument expanded the shear heap of the joint FSW in light of the fact that the higher propelling pace framed a slim and consistent intermetallic compound at the interface among aluminum and steel. However, very high propelling rates, for example, of 400 mm/min created the joint with a not-rectilinear intermetallic geometry, while the propelling pace of 200 mm/min delivered the joint with the right intermetallic geometry with most extreme shear load. The lap-shear burdens isn't relative to the propelling pace, the welded joint with the propelling rate of 200 mm/min plays out the most noteworthy lap-shear loads property, and a definitive shear strength is 3.6 KN.

## **I. INTRODUCTION**

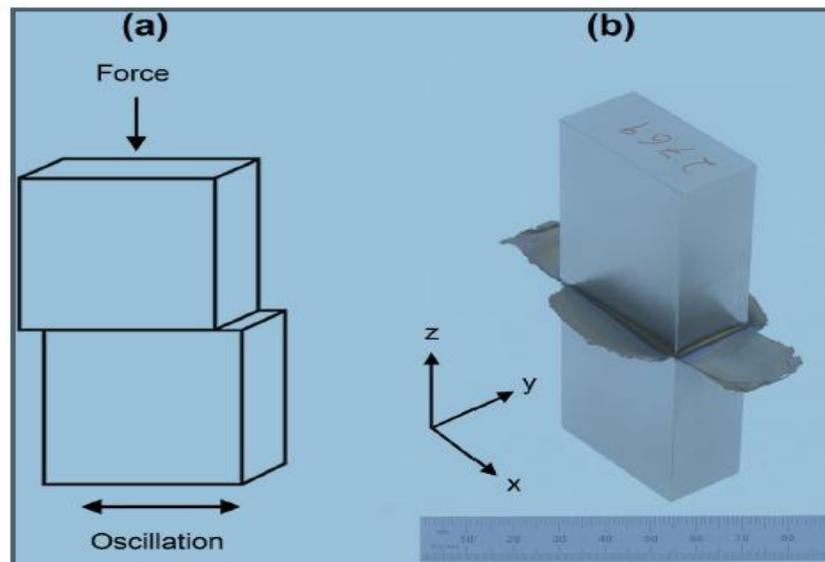
Direct contact welding (LFW) is a strong state joining process that works by wavering one work piece with respect to another While under a huge, compressive power; see (a). The grating between the wavering surfaces produces heat which makes the interface material plasticize. The plasticized material is then removed from the interface causing the work pieces to abbreviate (consume off) toward the compressive power During the consume off the interface contaminants, for example, Oxides and outside particles.

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**Fig. 1 (a)** LFW process schematic and **(b)** a completed Ti-6Al-4V well-meant showing the expelled interface material (flash)

## 1.2 Background

The straight grating welding procedure was first protected in the late 1920s, anyway there was almost no detail recorded on its utilization. An exchange of the procedure was then recorded in the USSR during the 1960s, yet it was depicted as being "Doubtful" as an assembling strategy to the trouble in creating responding direct movement. The primary Real organized industry examination into the procedure occurred at TWI, UK during the 1980s, while the main recorded scholarly research occurred at Ohio State University, USA and the University of Bristol, UK.

## 1.3 Process Phases

As recently expressed, direct grinding welding (LFW) is a strong state joining process that works by wavering one work pieces with respect to another while under a huge, compressive power, (a). Regardless of being one nonstop procedure, LFW is said to happen more than four stages Phase 1 – Initial stage. Minute contact exists between ill tempers on the two surfaces to be joined and warmth is produced because of rubbing (a). The ill tempers mellow and disfigure, expanding the genuine zone of contact between the Work pieces. Insignificant pivotal shortening (consume off) toward the applied power is seen during this stage.

There are eight process parameters used during linear friction welding

- 1) Oscillation frequency
- 2) Oscillation amplitude
- 3) Applied force/Normal force
- 4) Burn-off/Axial shortening/Upset
- 5) Ramp-up time (time taken for the amplitude and frequency to reach a steady-state level)
- 6) Oscillation decay time (time taken to decay the amplitude and frequency to a stop)
- 7) Forging force (the force used to help consolidate the weld post-oscillatory motion)
- 8) Forging force time (the time the forging force is applied)

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## 1.4 Bladed Disk (Blisk) Manufacturing

This is basically because of the costly cost of the original hardware and the way that most mechanical LFW machines are possessed by aviation producers. Until this point in time, the procedure is financially settled as an innovation for the manufacture of titanium composite incorporated bladed. Plates (blisks) in air motors. Titanium blisks are utilized in low temperature areas of air motors. Typically, Ti-6Al-4V (Ti-64) is utilized for applications up to 300 C and Ti-6Al-2Sn-4Zr-2Mo-0.15Si (Ti-6242) for applications up to 480 C. Moves Royce, MTU Aero Engines, General Electric and Pratt and Whitney all utilization the LFW procedure to economically deliver titanium combination blisks (a) demonstrates a case of a blisk fabricated utilizing the LFW procedure.

## 1.5 Ti-6Al-4V Linear Friction Welds

The LFW procedure is regularly utilized for joining metals, be that as it may, it has been utilized to join plastics. LFW is especially powerful for joining metals that have great high-temperature properties, for example compressive yield and shear quality, and low warm conductivities. This takes into consideration the created warmth to stay at the interface making the interface quickly heat and plasticize. This makes titanium composites especially reasonable for the procedure, anyway numerous comparative and divergent material blends have likewise been examined with differing degrees of accomplishment.

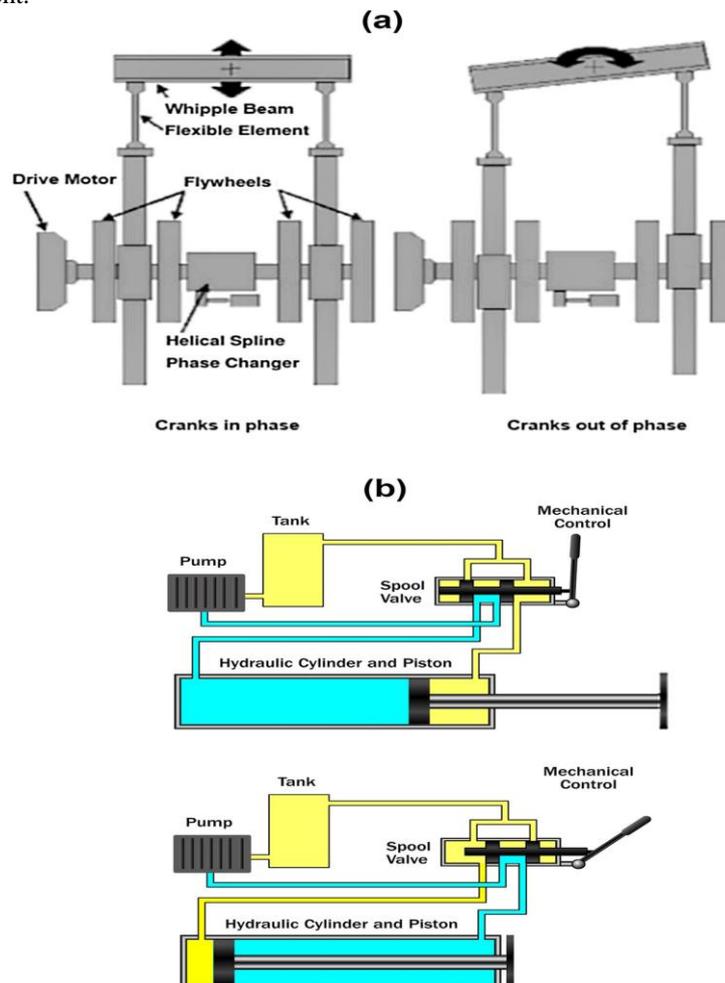


Fig -2. Schematic of (a) mechanically operated motion (image courtesy of TWI) and (b) hydraulically operated motion.

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Vol. 8, Issue 9, September 2019

## III. EXPERIMENTAL WORK

### 02.1 Introduction

In this experiment of friction welding, one end of the plate is fixed with the help of chuck and one end of the plate is welded to dead centre of tail stock. Then the plate attached to the chuck is rotated and the other plate is pushed towards it by applying pressure manually. In this chapter, the various experimental process of friction welding is described in detail.

### 2.2 Material Selection

Two mild steel plates of diameter 15cm and thickness 14mm are taken initially. One mild steel rod and one dead center of tail stock is taken for the experimental work.

Dimensions: Steel plate

Diameter: 15cm

Thickness: 14mm

### 2.2.1 Experimental set up



Fig-3 Experimental set-up for Friction Welding

### 2.2.2 Welding of MS Pole and Right on of Tail Stock to the Mellow Steel Plates

One gentle steel pole is welded to one gentle steel plate and perfectly focused of tail stock is welded to other plate. Mellow steel bar is taken, at that point focus of the plate was found and it was held by the assistance of tongue. At that point, it is welded by utilizing circular segment welding technique. Then, it is checked whether the welding is opposite or not. Subsequent to welding, we need to check whether it is appropriately welded or not. The welding of MS pole to gentle steel plate is finished by curve welding. One end of the other plate is welded to flawlessly focused of tail stock.

### 2.3 Observation

After getting the mellow steel plates according to the required dimension, we need to play out the analysis on a Lathe machine. First, one part is appended to throw of the machine and other part is fixed to tail stock. So, when the part connected to toss is turning and other part moves towards it by methods for utilizing weight manually. The hurl is to be

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Vol. 8, Issue 9, September 2019

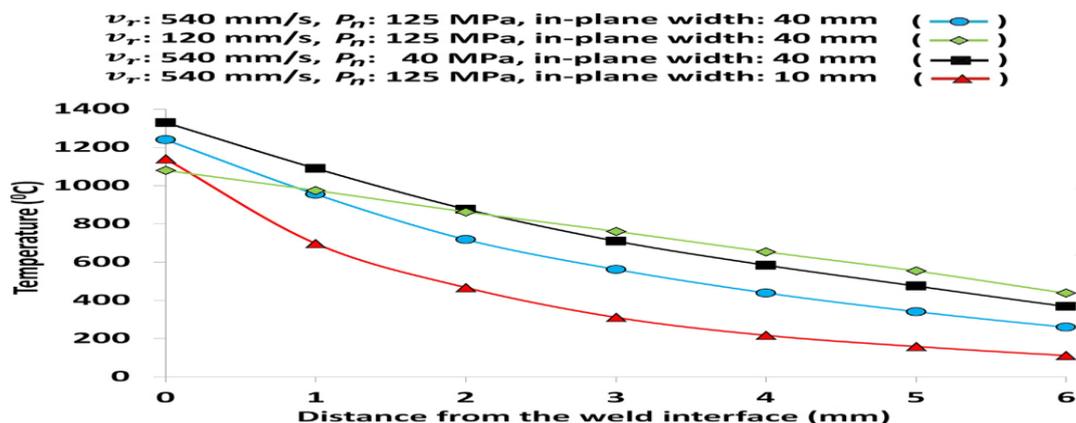
pivoted with a predetermined rpm and the tailstock part is to carried into contact with the pivoting part slowly. Initially the pivoting part is reached gradually and later on when the speed steadily builds the two sections come into contact and warmth is created in the contact region.

### 2.3.1 Various Grinding Welding Machines

NCT is an erosion welder and machine instrument developer. We have met the changed needs of our clients in the USA, Canada, Mexico and South America with specially crafted arrangements since 1983. NCT is prepared to retrofit or fix all current machine devices, and plan and convey welders or machine devices to address your issues.



Fig-4. Grinding Welding Machines



### 2.4 Mathematical Model

Thermal phenomenon modelling of the FSW process is based on the resolution of the thermal conduction equation in, the welded plates with an appropriate heat source model. In this work, a modified heat. Source model was considered, it represented the thermal flux source issued from the friction of the welding tool on the plates to be assembled considering the appropriate boundaries and initial conditions.

### 2.5 Heat Affected Zone

The HAZ is situated between the Thermo-Mechanically Affected Zone (TMAZ) and the Base Material (BM) (Fig. 4). This zone isn't compelled yet is presented to warm cycles which can bring about grains development. The grain in the HAZ is greater than those of base metal as a result of the high warm conductivity of aluminium amalgams. For warmth

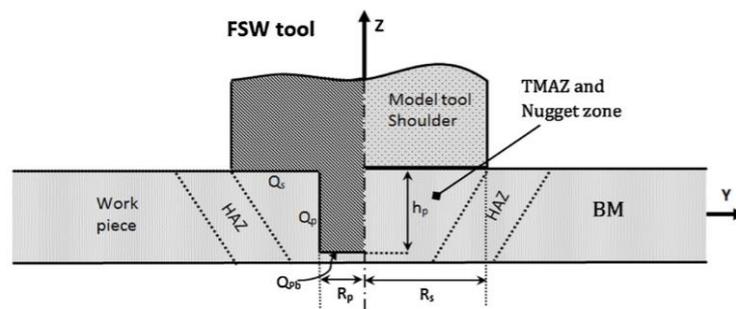
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Vol. 8, Issue 9, September 2019

treatable aluminium amalgams, the HAZ was distinguished as a zone encountering temperature over 250 °C [31]. Because of the poor mechanical properties of the HAZ, the disappointment more often than not happens in this zone during the tractable tests.



**Fig. 5** Generated heat distribution in a simplified FSW tool.

Thermo physical properties (warm conductivity and warmth limit) of working medium as elements of temperature are characterized. The compound thickness should be consistent and equivalent to 2700 kg/m<sup>3</sup>. For the remainder of the examination, the warm cycles results were determined what's more, remarked by six situations on the workpiece characterized by the focuses P1(L/2,5,H/4), P2(L/2,12.7,H/4)P3(L/2,25.4,H/4), P4(xi,5,H/2), P5(xi,5,0) and P6(xi,5,-H/2), as appeared in Fig. 6, where xi (I = 1,3) relates to three situations along X hub with qualities x1 = 305 mm, x2 = 450 mmnd x3 = 575 mm.

Numerical value		Initial	Optimal
<i>Heat input</i> (×10 <sup>6</sup> ) [W]		2.8789	1.7794
<i>T<sub>P1</sub></i>	[K]	764.45	649.70
<i>T<sub>P2</sub></i>	[K]	726.86	624.47
<i>T<sub>P3</sub></i>	[K]	691.31	600.48
<i>L<sub>Y1</sub></i>	[mm]	13.34	6.1323
<i>L<sub>Y2</sub></i>	[mm]	13.7070	6.3727
<i>L<sub>Y3</sub></i>	[mm]	18.9980	10.094
<i>u<sub>w</sub></i>	[mm/s]	2.3600	2.9012
<i>ω</i>	[rpm]	240.00	229.94
<i>F</i>	[N]	25000	19854
<i>R<sub>s</sub></i>	[m]	0.01270	0.01450

**Table No.1** Optimal parameters for the FSW process of AI-2195-T8 material

## IV. RESULT AND DISCUSSION

### 3.1Introduction

This chapter describes the results obtained after the experimental work and deals with the quality of the products by conducting of various tests. It also deals with the experiment requirements for materials other than steel.

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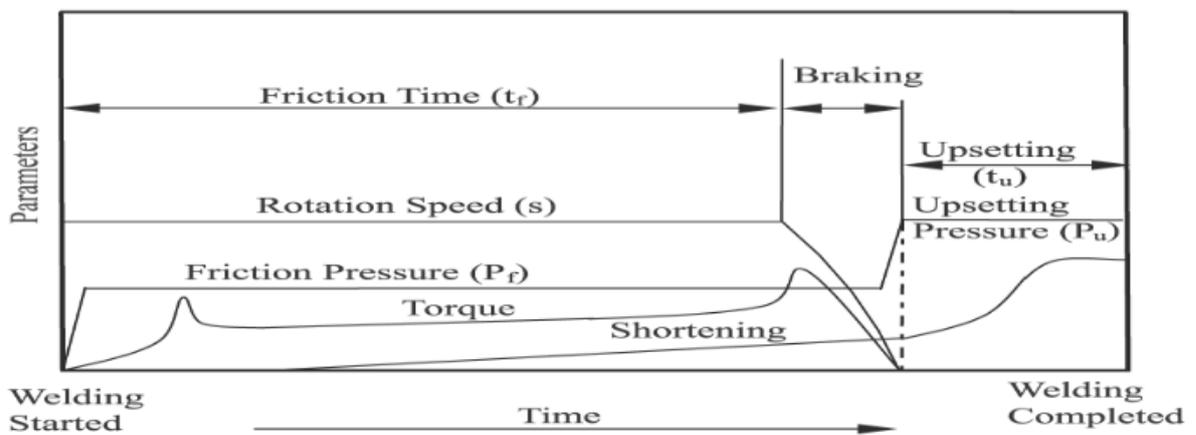
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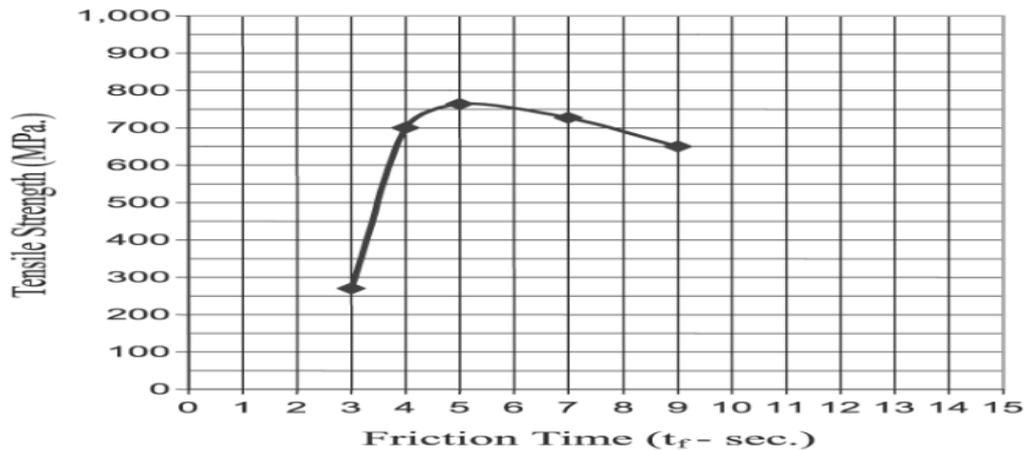
Vol. 8, Issue 9, September 2019

### 3.2 Quality

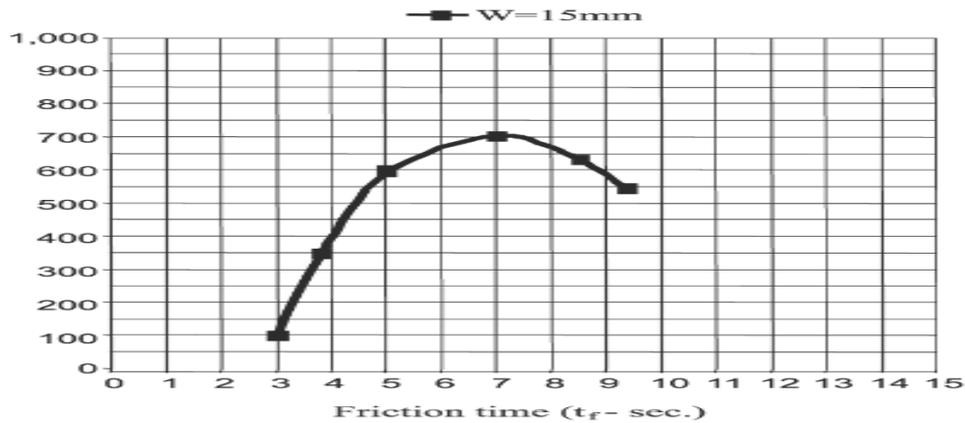
NCT's completely prepared Inspection and Metallurgical Laboratory empowers us to create and qualify the most testing of parts and procedures. Ruinous Testing is performed on the improvement weld during the weld advancement procedure to demonstrate material malleable and shear properties, and break down and check material microstructure.



**Fig-6.** Parameters for Continuous Drive Friction Welding



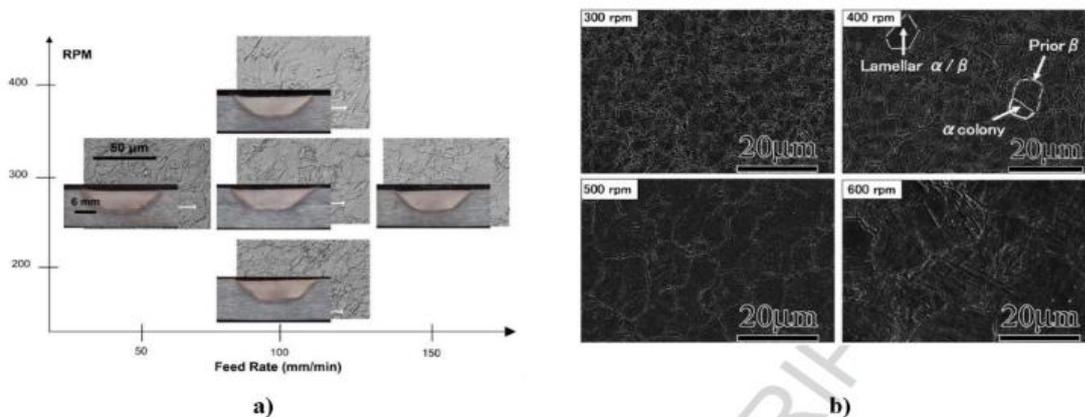
**Fig-7.** The Effect of Friction Time on the Tensile Strength



**Fig-8.**Effect of friction time on joint tensile strength  
(material: AISI 1040, Pf=30MPa, D/d=3)

### 3.3 Microstructure in WN, and TMAZ

Due to severe plastic thermo mechanical deformation the grains are refined in the WN. In the TMAZ/HAZ, deformation, and continuous dynamic recrystallization (CDRX) associated with higher temperature are in competition to define the microstructure in this region. Due to complex deformation, and the irregularity observed in the temperature profiles of the FSW of titanium alloys, the evolving microstructure, and the textures are persisted as the material flows around the tool and deposits in its wake. influence of rotation speed, and traverse speed has been observed in the microstructure of the WN for 12 mm thick Ti-6Al-4V. Nonetheless, higher rotation speed and lower traverse speed resulted in a coarser grained microstructure due to increased temperatures and extended exposure times. Zhang et al. [55] have demonstrated the effect of varying rotation speeds on FSWed 3 mm thick Ti-6Al-3V.



**Fig. 9.** a) Macrographs and micrographs of welds as function of rotation speed and traverse speed [32], b) SEM images of the WN produced at different rotational speeds. Lamellar  $\alpha/\beta$ , prior  $\beta$  and  $\alpha$  colonies are shown by arrows in the 400-rpm weld.

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Vol. 8, Issue 9, September 2019

## V. CONCLUSION

### 4.1 Conclusion

In this examination, the FSW joints of 6061-T6 aluminum composite and ultra-low carbon steel, in which the mixing pin was dove into steel (- 0.2mm) metal and remove the steel surface layer. The as-welded joint microstructures and properties were explored. The outcomes can be outlined as pursues:

- 1) The lap joint between A6061-T6 aluminum combination and ultra-low carbon steel was effectively delivered by FSW.
- 2) Increasing the propelling pace of an instrument expanded the shear heap of the joint FSW in light of the fact that the higher propelling pace framed a slim and consistent intermetallic compound at the interface among aluminum and steel. However, very high propelling rates, for example, of 400 mm/min created the joint with a not-rectilinear intermetallic geometry, while the propelling pace of 200 mm/min delivered the joint with the right intermetallic geometry with most extreme shear load. It is the ideal speed inside the conditions examined in this work.
- 3) The lap-shear burdens isn't relative to the propelling pace, the welded joint with the propelling rate of 200 mm/min plays out the most noteworthy lap-shear loads property, and a definitive shear strength is 3.6 KN.
- 4) The weld zone TMAZ and HAZ size abatement with expanding apparatus travel speed from 50 to 400 mm/min.

## REFERENCES

- [1] Altamer A. de. (2018) 'Automatic welding and cladding in heavy fabrication', Journal of Metallurgical Construction. pp 222-224.
- [2] Cary H. B. (2018) 'Modern Welding Technology'. New Jersey. Prentice Hall. pp 169-175.
- [3] Chan B, Pacey J, Bibby M. (2017) 'Modeling gas metal arc weld geometry using artificial neural network technology'. Journal of Canadian Metallurgical Quarterly. pp 43-51.
- [4] Cornu J. (2017) 'Advanced Welding Systems-Part2'. London, IFS Limited. pp 168.
- [5] Essers W. G. and Walter R. (2018) 'Heat transfer mechanisms with GMA and plasma-GMA welding'. Welding Journal, (3): pp 69-76.
- [6] Grainger S. (2015) 'Developments in weld surfacing for the process industries', Proceedings of International Symposium on Welding Allied Developments for the Process Industries', London. pp 12-14.
- [7] Gunnert R. (2017) 'Penetration and travel speed in metal arc welding'. Welding Journal, Vol. 27: pp 542.
- [8] Gupta V.K. and Parmar R.S. (2016) 'Fractional factorial technique to predict dimensions of the weld bead in automatic submerged arcwelding'. pp 67-75.
- [9] Gurev H. S. and Stout, R. D. (2016) 'Solidification phenomenon in inert gas metal arc welding'. Welding Journal, 42(7): pp 298-310.
- [10] Jackson C.E. and Shrubbsall A.E. (2017) 'Control of penetration and melting ratio with welding technique'. Welding Journal, 32(4): pp172-178.
- [11] Kearns W. H. (2017) 'Welding Processes. Welding Handbook', Vol.2, 7th Edition. American Welding Society, Miami, Macmillan, pp113-187.
- [12] Kim I.S, Son J.S, Kim I.G, Kim O.S. (2003) 'A study on relationship between process variable and bead penetration for robotic CO<sub>2</sub>arc welding'. Journal of Material Process.
- [13] Kim I.S, Son K.J, Yang Y.S, Yarangada P.K.D.V. (2017) 'Sensitivity analysis for process parameters in GMA welding processes using a factorial design method'. International Journal of Machine Tools Manufacturing, pp 763-769.
- [14] Kjeld F. (2016) 'Gas metal arc welding for the collision repair industry', American Welding Journal, 70(4): pp 39-46.
- [15] Kannan T and Murugan N. (2016) 'Effect of flux cored arc welding process parameters on duplex stainless steel clad quality'. Journal Material Process Technology, pp 230-239.
- [16] Lyttle K.A. (2016) 'GMAW- A versatile process on the move', American. Welding Journal, 62(3): pp 15-23.
- [17] Madatov N. M. (2017) 'Shape relationships for underwater welding'. Welding Production, 16(3): pp 18-23.
- [18] McGlone J. C. (2017) 'Weld bead geometry prediction-A review'. Metal Construction, 14(7): pp 378-384.